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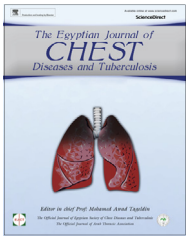

ORIGINAL ARTICLE

Compliance with VAP bundle implementation and its effectiveness on surgical and medical sub-population in adult ICU

Kamel Abd Elaziz Mohamed

Critical Care Medicine, Cairo University, Egypt

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KEYWORDS

VAP Bundle-ICU;
Compliance

Abstract *Introduction:* Despite broad implementation of a bundled strategy aimed at preventing ventilator-associated adverse events in many hospitals, the ability of the bundle to prevent VAP has not been definitively established with high-quality studies.

Aim of the work: To implement VAP bundle as a performance improvement project in adult ICU and follow up the compliance rate over the 12 month study period as well as the effectiveness on surgical and medical subgroups.

Patients and method: VAP Bundle Program was implemented in adult ICU, data were collected and analyzed for ventilated-associated pneumonia (VAP), and compared before and after intervention. Our bundle components were head of bed elevation greater than 30°, daily sedation break, assessment for extubation, peptic ulcer prophylaxis and deep vein thrombosis prophylaxis.

Results: The results clearly show the difference between pre and post-intervention period and lower VAP rate after application of VAP bundle. The total VAP bundle compliance rate steadily increased during the period of implementation. We documented a significant reduction of mean ICU LOS (from 15.4 ± 5.2 to 10.8 ± 4.9 days) and duration of mechanical ventilation (from 12.8 ± 4.9 to 8.5 ± 4.3 days) for patients with VAP bundle compliance at the end of the study. There was a significant improvement in the outcome of surgical patients who were studied after VAP bundle initiation reflecting a decreased mortality rate.

Conclusion: Our study highlights that adherence with the VAP-bundle approach in our ICU decreases the incidence of VAP, more rapid ventilator weaning, fewer ICU days, and shorter

E-mail address: kamel.abdalla64@gmail.com

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hospitalizations and it has also a great impact on patient outcomes. Our study looked into surgical sub-population as getting more benefit by initiation of the VAP bundle in reducing the length of stay. Thus it results in a decrease in the burden of the health care costs and the ICU resources.

Introduction

Ventilator-associated pneumonia (VAP) is an airway infection that must have been developed more than 48 h after the patient was intubated. It has been reported to occur in 9–27% of all intubated patients [1]. The overall rate of ventilator-associated pneumonia (VAP) was 13.6 per 1000 ventilator days according to International Nosocomial Infection Control Consortium (INICC) report data summary for 2003–2008 compared to 3.3 per 1000 ventilator-days in the US National Healthcare Safety Network (NHSN; formerly the National Nosocomial Infection Surveillance system (NNIS) [2,3]. Importance of this issue reflects the high incidence and making VAP among the most common infection in ICUs and the high cost of treatment ($11 000–$57 000) with a greater number of days in the intensive care unit (ICU), longer duration of mechanical ventilation, and higher mortality [4]. Awareness of the gap between guideline dissemination and clinical practice has led to efforts by individual hospitals and health care systems to institute programs aimed at complying with VAP prevention guidelines to reduce the burden of this nosocomial infection [5]. Reducing mortality due to ventilator-associated pneumonia requires an organized process that guarantees early recognition of pneumonia and consistent application of the best evidence based practices [6]. The Ventilator Bundle is a series of interventions developed by the Institute for Healthcare Improvement (IHI) related to ventilator care that, when implemented together, will achieve significantly better outcomes than when implemented individually [7,8]. The IHI ventilator bundle has been broadly adopted by many hospitals as part of the effort to reduce VAP. The use of VAP bundle has been reported to decrease the incidence of VAP in the intensive care units (ICUs) in few studies [8]. No large randomized study has demonstrated that reducing VAP using any VAP prevention strategy, including those in the IHI bundle, is associated with improvements in clinical outcomes. More recently a multidimensional strategy that included a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices was associated with a significant reduction in VAP rate in neonatal ICUs in developing countries [9].

The main objective of this study was to implement VAP bundle as a performance improvement project in the critical care unit for all mechanically ventilated patients aiming to decrease the VAP rates. Secondly to follow the compliance rate over the 12 month study period and analyze the effectiveness of the implementation of ventilator bundle on surgical and medical subgroups.

Patients and method

This study was conducted in our adult medical ICU of Manial Specialist Hospital in Cairo university. VAP Bundle Program was implemented in September 2012 by our team and our study was initiated through retrospective review of prospectively collected data from infection control. Reports from ICU for the period from September 2011 to August 2012 were reviewed. All the adult medical and surgical patients who were intubated and ventilated in our ICU from September 2012 to August 2013 were included in the study. The critical care nurses and the staff were educated and made aware about the problem of VAP and the use of ventilator bundle in helping to decrease this nosocomial infection. Patients who were transferred to other hospital or expired within 48 h of admission, and those who were diagnosed with pulmonary embolism or had gastrointestinal bleeding prior to admission were excluded from this study.

Data were collected and analyzed for ventilated-associated pneumonia (VAP) for the mentioned period of time and compared before and after intervention. Patients were included if they were mechanically ventilated for more than 48 h and were at least 18 years of age. A day on mechanical ventilation was defined as any 24 h period in which the patient required any mode of controlled or assisted ventilation, with the exception of intermittent application of continuous positive airway pressure for atelectasis prophylaxis. Assignment of patients to nursing staff and clinicians was not controlled by the study protocol, routine laboratory study including ABG was done. Standard unit measures of general critical care were applied to all patients, including the current practice of hand washing, tracheal suction, and daily oral care. The medical management, antibiotic therapy, and weaning from the ventilator were left to the treating physician's discretion. Our bundle components are as follows:

(1) Head of bed elevation greater than 30°.
(2) Daily sedation break.
(3) Daily assessment for extubation.
(4) Peptic ulcer prophylaxis.
(5) Deep vein thrombosis prophylaxis.

Compliance was assessed twice daily by the ICU team. Ventilator associated pneumonia (VAP) was defined as per the Center of Disease Control (CDC) as a pneumonia that occurs in a patient who was intubated and ventilated at the time of or within 48 h before the onset of the event. Pneumonia was identified using a combination of radiological, clinical, and laboratory criteria. In our study VAP was clinically diagnosed based on modified CDC criteria [10]. Presence of any two of the following was considered as diagnostic of VAP.

(1) Significant heavy growth reported in the culture from tracheal aspirates.
(2) Temp.: >38 °c or <35 °c.
(3) Development of progressive new infiltrate on X-ray.
(4) Leukocytosis WBC $>10\times10^9$/L or leucopenia WBC $<3\times10^9$/L.
(5) Ten leucocytes per HPF in gram stain of tracheal aspirates.

VAP rates were calculated based on occurrences per 1000 ventilator days and monitored on a monthly basis throughout the project period.

Incidence of VAP was calculated in the medical and surgical sub-populations who were subjected to VAP bundle. The outcome measures that were analyzed were mean length of stay, mean duration of ventilation, and the incidence of gastrointestinal bleeding.

Teams conducted regular daily rounds on all ventilated patients and recorded compliance with the five elements of the VAP bundle. The entire bundle was considered compliant only if all 5 items were completed. A bundle was considered non-compliant if any item was not performed, even if that item was contraindicated. The only exception was contraindication to deep vein thrombosis prophylaxis in patients with head injury; the bundle was still considered compliant in this case. We were very concerned about the delay of antibiotic therapy, even for just a few hours, in this susceptible population. Therefore, because survival is improved in the patients receiving appropriate empirical antibiotics, guidelines recommend the coverage of all potential pathogens responsible for an episode of ventilator-associated pneumonia (VAP). Collection of bronchial specimen precedes the administration of empirical antibiotics [10]. The choice of antibiotics is based on the presence of specific risk factors. After the responsible bacteria in samples were identified, guidelines recommend reassessing the antibiotic treatment. Quantitative variables are presented as mean ± SD and qualitative data are given as number and percentage. Normal distribution of data was tested via Kolmogorov–Smirnov test and by Fisher's exact test for categorical variables. All tests were two-sided, and $p < 0.05$ indicated a statistical significance.

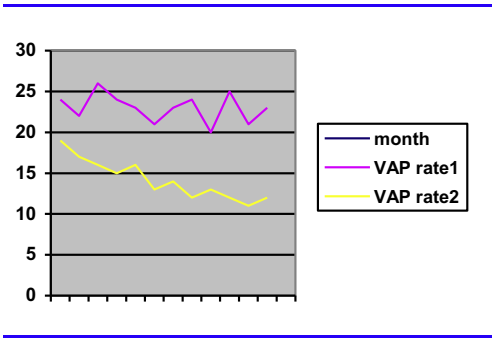

Figure 1 VAP bundle compliance rates and VAP rates in ICU over the study period.

Results

The total number of patients requiring mechanical ventilation in the previous year of the VAP bundle initiation were 105 patients and the cumulative VAP incidence was 34%. On the other hand we studied 98 ventilated patients subjected to VAP bundle with cumulative VAP incidence 18%. The mean age of patients who were studied after VAP bundle initiation was insignificantly lower than those before VAP bundle and there is no significant difference in sex distribution in the current studied population.

The data were analyzed and compared on monthly basis based on 1000 ventilator days. The rate of VAP raised up to 26/1000 ventilator days during the period from September 2011 to August 2012 and declined by the end of July 2013 to be as low as 11/1000 ventilator days. The results clearly show the difference between pre and post-intervention period and lower VAP rate after application of VAP bundle. This correlated with a decrease in the annual VAP rate from 23 per 1000 ventilator days before VAP bundle down to 14 per 1000 ventilator days after VAP bundle initiation. Lower VAP rate was prospectively recorded in July before the end of the study (Fig. 1). Statistical process control chart that monitored the implementation of VAP bundle on a monthly basis has revealed an improvement in compliance rate in the ICU. Compliance with all measures just after VAP bundle implementation was as low as 57%. A level as high as 90% of total compliance rate was only achieved at the last 3 months of the study. The total VAP bundle compliance rate steadily increased from 63% to 84% during the period of implementation. We documented a reduction of mean ICU LOS (from 15.4 ± 5.2 to 10.8 ± 4.9 days) and duration of mechanical ventilation (from 12.8 ± 4.9 to 8.5 ± 4.3 days) for patients with VAP bundle compliance at the end of the study. However, there was no statistically significant difference in APACHE score. The reduction in the incidence of upper gastrointestinal bleeding was statistically significant after VAP implementation (Table 1).

Efforts on VAP prevention and outcome improvement should focus on achieving higher compliance in DVT

Table 1 Characteristics of patients included in the study before and after VAP bundle initiation.

	Before VAP bundle	After VAP bundle	*P*-value
Age(years)	61.8 ± 5.6	57.7 ± 4.6	0.08
Male/female	69/36	67/31	0.6
LOS in ICU	15.4 ± 5.2	10.8 ± 4.9	0.036
Duration of MV	12.8 ± 4.9	8.5 ± 4.3	0.038
APACHE score	21.4 ± 4.2	20.6 ± 5.1	0.1
upper GIT bleed	16%	3%	0.01
Incidence of VAP	(36) 34%	(18) 18%	0.026
Re-intubation rate	(27) 26%	(16) 16%	0.039
Mortality	(24) 23%	(15) 15%	0.04

LOS in ICU: length of stay in ICU(days), Duration of MV: duration of mechanical ventilation, (*n*) %: number, percentage.

Table 2 VAP bundle compliance rates at 1st quarter and last quarter of the study.

	1st quarter Mean compliance, % (range)	4th quarter Mean compliance, % (range)	*P*-value
HOB elevation	76 (71–82)	85 (77–93)	0.04
Sedation break	76 (71–80)	92 (91–94)	0.03
Assessment for extubation	92 (87–97)	93 (92–95)	0.1
PU prophylaxis	87 (84–91)	94 (93–96)	0.045
DVT prophylaxis	78 (73–84)	96 (95–98)	0.018
Total compliance	63 (57–69)	84 (72–90)	0.02

HOB elevation: head of bed elevation, PU prophylaxis: peptic ulcer prophylaxis DVT prophylaxis: deep vein thrombosis prophylaxis.

Table 3 Results of deep tracheal aspirate of the studied patients.

Organism	1 (%)	11 (%)
Pseudomonas aeruginosa	(33) 31	(24) 24
Klebsiella pneumoniae	(31) 29	(26) 26
Acinetobacter baumannii	(10) 9	(11) 11
Stenotrophomonas maltophilia	(7) 7	(8) 8
MRSA	(4) 4	(2) 2
Serratia marcescens	(3) 3	(4) 4
Candida	(5) 5	(9) 9
Others	(12) 11	(16) 16

1: before VAP bundle initiation, 11: after VAP bundle initiation. (*n*)%: number percentage, MRSA: Methicillin-Resistant *S. aureus*.

Table 5 ABG, serum electrolyte and lactate at the onset of VAP.

pH	7.25 ± 0.02	7.33 ± 0.05	0. 07
PaO_2 (mmHg)	50 ± 5.33	49.77 ± 6.8	0.09
$PaCO_2$ (mmHg)	39.35 ± 4.26	38.65 ± 5.08	0. 1
HCO_3 (meq/L)	19.35 ± 2.86	20.42 ± 3.36	0.08
SO_2 (%)	79.40 ± 4.65	83.98 ± 6.08	0.07
Na (mEq/L)	135.3 ± 5.14	134.8 ± 4.72	0.5
K (mEq/L)	3.89 ± 0.59	3.73 ± 0.47	0.2
Lactate (mmol/L)	2.4 ± 0.72	2.2 ± 0.5	0.13

prophylaxis and PU prophylaxis followed by sedation break and the head of the bed at 30° or more (Table 2). Pseudomonas aeruginosa being the most common organism was isolated from deep tracheal aspirate followed by Klebseillae pneumoniae and Acinetobacter baumannii in both periods whether before or after VAP bundle (Table 3). There were no significant difference in hemodynamics, hemoglobin, leukocytic count, ABG and electrolyte at the onset of VAP either before or after VAP bundle initiation (Tables 4 and 5). On the other hand, focusing on surgical subgroup after VAP initiation revealed that both the age and length of stay were significantly lower than the medical subgroup. The mean duration of ventilation and re-intubation rate were significantly higher in the medical subgroup (Table 6). The improvement in outcome of surgical patients who were studied after VAP bundle initiation reflected in a significant decrease in the rate of GIT bleeding as well as the mortality rate at the end of the study.

Discussion

VAP occurs in up to 15% of patients receiving mechanical ventilation. Risk factors include tracheostomy, multiple central line insertions, reintubation, and the use of antacids [11]. The hospital mortality rate of ventilator patients who develop VAP may be as high as 46%, compared to 32% for ventilator patients who do not develop VAP [12]. The IHI has developed a ventilator bundle that incorporates several strategies to prevent morbidity associated with the ventilator. Three elements of this bundle target VAP while 2 elements address prevention of stress ulcers and thromboembolic disease [8]. Despite broad implementation of a bundled strategy aimed at preventing ventilator-associated adverse events in many hospitals, the ability of the bundle to prevent VAP has not been definitively established with high-quality studies [2]. Our study demonstrates that if no VAP bundle is implemented, it is obvious that VAP rates will continue to remain high as it rose up to 26 per 1000 ventilator days before VAP bundle initiation. On the other hand the lowest VAP rate was prospectively recorded in July before the end of the study. Even though there was an improvement in the process of bundle compliance rate in ICU with some variation and the process became stable the target of total compliance rate of 95% was never reached. Therefore, the process would have been considered acceptable as this correlated with a decrease in the VAP rate in our ICU. The highest compliance rate with DVT prophylaxis and PU prophylaxis followed, by sedation break and lastly the head of the bed at 30° or more was achieved by the end of the study.

Table 4 Hemodynamics, hemoglobin and leukocytic count at the onset of VAP.

Parameter	1	11	*P*-value
Pulse (beats/min)	105.1 ± 9.8	102.8 ± 7.1	0.7
MBP (mmHg)	74.6 ± 11.0	71.2 ± 13.2	0.8
Respiratory rate (breaths/minute)	25.2 ± 6.7	26.1 ± 5.5	0.6
HB	9.6 ± 3.8	10.4 ± 2.7	0.09
WBCs/mm3	14.72 ± 3.51	15.5 ± 2.29	0.07

1: before VAP initiation, 11: after VAP initiation, MBP: mean arterial blood pressure, HB: hemoglobin, WBCs: white blood cells.

Table 6 Difference between surgical and medically ventilated patients after VAP bundle application.

	Surgical patients	Medical patients	*P*-value
Age(years)	47.3 ± 6.2	65 ± 5.2	0.03
Male/female	23/16	34/25	0.2
LOS in ICU	6.6 ± 5.3	13.7 ± 4.6	0.0 2
Duration of MV	5.24 ± 6.6	11.9 ± 6.3	0.02
APACHE score	18.3 ± 4.6	21.2 ± 6.6	0.08
Upper GIT bleed	(0) 0%	(3) 5%	0.04
Incidence of VAP	(4) 10%	(14) 24%	0.038
Re-intubation rate	(3) 8%	(13) 22%	0.02
Mortality	(3) 8%	(12) 20%	0.0 32

(*n*) %: number, percentage, LOS: length of stay.

After the end of the study the compliance, VAP rates, intensive-care unit length of stay (ICU LOS) and duration of mechanical ventilation were evaluated. Our study reported that a 34% of ventilated patients in our ICU developed VAP before initiation of VAP bundle. This reflects the major problem that faces us and the stimulus to start improvement in a resource limited environment including lack of nursing staff, individual variability. Most studies have reported a varied incidence from 17% to 30%, depending upon the diagnostic criteria of VAP [13,14]. The reported incidence of VAP was higher in academic institutions [15]. The decrease in the mean length of stay and mean duration of ventilation was statistically significant in our patients subjected to VAP bundle. However, another study evaluating these components of the bundle reported a 95% adherence with the bundle and an associated reduction in VAP, but investigators acknowledged that the reduction may have been related to a concurrent improvement program that focused on care of the ventilated patient [16]. The decrease in the incidence of gastrointestinal bleeding was statistically significant during the period of implementation of VAP bundle as this could be attributed to high compliance to PU prophylaxis which was supported by Zaydfudim et al. [17]. We tried to study separate subpopulations in the same intensive care unit in the period of VAP implementation aiming to address its effect on the patient subpopulation and help to determine the factors which prevent the effectiveness of this practice.

The higher rate of VAP in medical subgroup after the bundle was implemented could be attributed to higher mean age of this population as the age and other co-morbidities are independent risk factors for the development of VAP in critically ill patients [12]. Another factor that helps in decreasing the rate of VAP in surgical subgroup was a lower re-intubation rate which may be a reason for limiting aspiration pneumonia and infection. Furthermore the pathogenesis of VAP commences in most cases with the bacteria entering the trachea during initial intubation, during subsequent re-intubations as this was studied by Wahl et al. when they reviewed more than one hundred surgery and trauma patients who underwent BAL within 48 h of intubation. They found that 90% of specimens had some growth and 58% had at least 104 colony forming units/ml. Patients subsequently diagnosed with VAP often grew the same organisms as they were present on the initial BAL. On the basis of this, they proposed that many events labeled as VAP are present or incubating on admission and hence are not preventable [18]. Two studies from India have shown contrastingly high VAP rates of 32.5% and 20% in children ventilated in Pediatric Intensive Care Units (PICU) [19,20]. In a recently published study from a tertiary care center in north India, the incidence of VAP was reported as 17.5% [21].

Most of organisms responsible for VAP in the current study are multiresistant and require a higher broad spectrum of antibiotics for more than 7 days for cure. Thus this results in longer length of stay and prolonged use of ventilator support than that reported by Song et al. [22]. There is always a threat to the other patients of getting this infection as a result of cross contamination through the hands of the health care workers. Our study showed that pseudomonas aeruginosa followed by klebsiella pneumoniae was the most common organism in the culture whether before or after VAP bundle application a matter that could be again explained by lack of concentration in different infection control measures at the study. An important observation from our study was that the rate of death in the intensive care unit appeared lower in ventilated patients after initiation of VAP bundle despite the fact that we did not study the individual risk factors, however APACHE score which allows an assessment of the severity of disease showed no significant difference before or after initiation of VAP bundle. It is also possible that decreased rate of re-intubation was the reason for the significant decrease of mortality, through a number of mechanisms such as cardiac ischemia, aspiration pneumonitis, and complications of emergency intubation and infection [23].

A fact that may have added more value to VAP bundle application in our study is, in spite of infection control measures playing a role in VAP prevention, our study did not look into the different infection control measures at the study hospitals. Furthermore the general preventive measures of hand hygiene and circuit care are not a part of this bundle. The benefits in terms of decreased length of stay and decreased duration of ventilation were also reflected on the cost. The limitations of our study are a small population studied and hence a collaborative multi-center cohort study to be conducted in many adult intensive-care units. Further individual risk factors which predispose the patients to the development of VAP have not been considered. In conclusion, our study highlights that adherence with the VAP-bundle approach in our ICU decreases the incidence of VAP, more rapid ventilator weaning, fewer ICU days, and shorter hospitalizations and it has also a great impact on patient outcomes. Our study looked into surgical sub-population as getting more benefit by initiation of the VAP bundle in reducing the length of stay. Thus it results in a decrease in the burden of the health care costs and the ICU resources.

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